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(54) [Title of the Invention] SEMICONDUCTIVE BELT AND IMAGE FORMING APPARATUS INCLUDING THE SAME

(57) [Abstract]

[Object] To provide a semiconductive belt with low resistance variation due to the applied voltage or expansion/contraction in the vicinity of a support roll, and an image forming apparatus capable of obtaining stably an image of high quality.

[Construction] A semiconductive belt and an image forming apparatus including the same characterized in that a relationship between an initial volume resistivity ρv1 (Ωcm) and a volume resistivity ρv2 (Ωcm) after applying a tensile repeated distortion of 3% to the belt 10,000 (10K) times satisfies Expression (1) below.

Expression (1) $|\log\rho v1-\log\rho v2|\leq 0.5$

[Claims]

[Claim 1] A semiconductive belt characterized in that a relationship between an initial volume resistivity ρv1 (Ωcm) and a volume resistivity ρv2 (Ωcm) after applying a tensile repeated distortion of 3% to the belt 10,000 (10K) times satisfies Expression (1) below.

Expression (1) $|\log\rho v1 - \log\rho v2| \leq 0.5$.

[Claim 2] The semiconductive belt according to claim 1, wherein the initial volume resistivity is 10^{7} to 10^{11} Ωcm.

[Claim 3] The semiconductive belt according to claim 1 or 2, wherein the belt contains at least two incompatible materials.

[Claim 4] The semiconductive belt according to any one of claims 1 to 3, wherein the belt is provided with a surface coating layer made of low-surface energy material.

[Claim 5] The semiconductive belt according to claim 4, wherein the low-surface energy material is dispersed with particles of fluorine resin.

[Claim 6] An image forming device including a transfer carrying belt for carrying a body to be transferred to a transfer region in which a toner image is transferred onto the transfer body, the transfer carrying belt being a semiconductor belt according to any one of claims 1 to 5.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs] The present invention relates to a semiconductive belt used in belt transfer, toner image transfer, a transfer portion of a sheet

or the like in an image forming apparatus using electrophotography such as an electrophotography copier, a printer, facsimile, or a complex machine thereof.

[0002]

[Prior Art] Conventionally, as a transfer carrier belt for image formation used in a transfer carrier device of an image forming apparatus, an elastic material such as rubber, thermoplastic elastomer, or the like has been proposed from the viewpoint of easy control of the driving of a belt. For example, a belt using thermoplastic elastomer has been proposed in Japanese Patent Application Laid-Open No. H2-10389. However, the belt made of thermoplastic elastomer is likely to be deformed due to the property of the material. In particular, in a case where the belt is movably suspended between roll-shaped supports, there is a problem in that when the belt is stopped for a long time, it is likely to be deformed along a curvature of the support, so that a transfer material is not electrostatically absorbed and stably carried.

[0003] In addition, Japanese Patent Application Laid-Open No. H2-264277 suggests the use of a belt wherein a polyethylene film is laminated on an EPDM rubber having an intrinsic volume resistivity of 10^{15} to 10^{16} Ωcm. Furthermore, Japanese Patent Application Laid-Open No. S63-83764 suggests a semiconductive belt or the like wherein an elastic body is used as a material having an intrinsic volume resistivity of about 10^{10} to 10^{13} Ωcm. Since the semiconductive belt is made of an elastic body, the belt has a higher tensile strength

than elastomers. The transfer semiconductive belt for forming an image is required to have given paper-passing durability as well as a high tensile strength. About this paper-passing durability, a good performance is obtained by setting the thickness of the belt to a given thickness.

[0004] In the case in which the following is used in order to obtain such a high tensile strength and given paper-passing durability: for example, the transfer carrying belt described in the Japanese Patent Application Laid-Open No. H2-264277, having an intrinsic volume resistivity of 10^{15} to 10^{16} Ωcm, or the transfer carrying belt described in the Japanese Patent Application Laid-Open No. S63-83764, having an intrinsic volume resistivity of about 10^{10} to 10^{13} Ωcm, there arises a problem that an electric field necessary for the transfer becomes large so that a heavy burden is imposed on a power source for applying voltage to the belt. Since the transfer carrying belt holds a transfer material through electrostatic absorption power, discharge of electricity may be generated when the transfer material is separated from the belt. In this case, a transfer image on the surface of the transfer material may be disturbed. This discharge is easily generated particularly under environment of a low temperature and low humidity. However, in the case in which the semiconductive belt having a high intrinsic volume resistivity is used as the transfer carrying belt, a high voltage is necessary for holding the transfer material by means of the belt; therefore, discharge of electricity is

easily generated. This discharge phenomenon causes some parts of toner on the surface of the transfer material to reverse polarity. Thus, transfer defects are generated so that image defects called pinhole are caused in some parts of the transfer material surface. Thus, the transfer image is easily disturbed to result in a problem that a good image quality is not easily obtained.

[0005] In the case in which the intrinsic volume resistivity of the transfer carrying belt is less than 10^8 Ωcm, electric charges flow easily, thereby resulting in a problem that the transfer material cannot be held through electrostatic absorption power.

[0006] Japanese Patent Application Laid-Open No. H8-185068 suggests, as a transfer carrying belt, a belt wherein the surface of an elastic body having a intrinsic volume resistivity of 10^3 Ωcm or less, such as chloroprene, is coated with a nylon resin or a urethane resin. In the case in which the surface layer of the chloroprene is coated with the nylon resin, the surface coat layer cannot follow deformation of the transfer carrying belt at a curvature portion, where the belt passes through a roll-shaped support, since the coat layer is hard. Thus, a crack may be generated in the surface layer. In the case of the urethane resin coat, the coat layer has flexibility not to cause a problem of the generation of a crack on the coat layer surface as described above. However, this belt has a problem that toner adheres easily to the surface so that the surface easily gets dirty.

[0007] In the case in which an elastic body such as chloroprene in which carbon black or the like is dispersed is used for the transfer carrying belt, a desired stable resistance value can hardly be obtained even if ordinary conductive carbon black is added to ordinary rubber material. This is because a semiconductive resistance range having a resistivity of about 10^{8} Ωcm is a range wherein resistivity is not easily controlled. As a result, it is difficult that variation in the resistance of the belt using the abovementioned elastic body is stably set in such a manner that the common logarithm of the volume resistance thereof is within one figure (logΩcm value). In the case in which in-plane variation in the resistance is one figure or more, transfer voltage cannot be uniformly applied. Therefore, a problem arises that image quality after transfer is not stable.

[0008] In order that the semiconductive belt holds the transfer material and a toner image is transferred onto the transfer material, a transfer voltage of 1 kV to 5 kV is applied. This applied voltage causes a change in the resistance of the belt material, resulting in a problem that a difference in the resistance value of the belt is generated between the region where the transfer material is present and the region where it is not present.

[0009] To overcome a change over time in the resistance value of the abovementioned belt material and unevenness of the belt resistance value, Japanese Patent Application Laid-

Open No. H8-292648 suggests a transfer carrying belt formed of three layers wherein the intrinsic volume resistivity of the first layer (surface layer) is set within the range of 1×10^{10} to 1×10^{16} Ωcm; a rubber layer using the conductivity of a polymer itself, the intrinsic volume resistivity range thereof being from 1×10^{7} to 1×10^{10} Ωcm, is used as the second layer (intermediate layer); and the intrinsic volume resistivity of the third layer (base layer) is set within the range of 1×10^{10} to 1×10^{16} Ωcm. This publication states that the unevenness of the resistance value can be improved by the rubber layer using the conductivity of the polymer itself, which is the second layer (intermediate layer). However, in the case of the laminated belt, the resistance value thereof is controlled by the layer having a high resistance value. Thus, the unevenness of the resistance value is not sufficiently overcome.

[0010] Furthermore, Japanese Patent Application Laid-Open No. H9-179414 suggests a rubber material made of chloroprene rubber and EPDM (ethylene propylene diene monomer) as a countermeasure against the change over time in the resistance of the belt material. However, this suggestion is insufficient for overcoming this change over time and the unevenness of the belt resistance.

[0011] Furthermore, Japanese Patent Application Laid-Open No. H7-271204 suggests the use of an ion-conductive type rubber material made of a rubber material having an intense polarity, such as hydrin rubber, as a countermeasure against the change

over time in the resistance value of the belt material and the unevenness of the belt resistance value. In the case of using an electroconductive type rubber material using a conductive agent such as carbon black, a problem of a change in the resistance value does not arise between a high temperature with high humidity and a low temperature and low humidity. However, the ion-conductive type rubber material has a problem that the resistance value thereof changes by 1 figure or more between a high temperature and high humidity and a low temperature and low humidity.

[0012] In a material system using the conductive agent such as carbon black, there is no prior art that deals with the change over time in the resistance of the belt material and the resistance variation of the tensile repeated distortion.

[0013]

[Problem to be Solved by the Invention] As described above, the related art has a problem in that in-plane variation of the belt is high and the resistance of a part of the belt material is varied by the transfer voltage in the region of 10^{8} Ωcm to 10^{11} Ωcm in which the transfer image is not disturbed. In particular, if the variation of the belt resistance caused by the transfer voltage (applied voltage) or the like is high, there is a problem in that since the transfer failure occurs partially, a good quality of image cannot be obtained.

[0014] Since the resistance variation occurs in a part of the belt material due to the transfer voltage, the belt

material is frequently exchanged, which results in the effort for maintenance and the increase in a running cost. As a result, it is not desirable.

[0015] Conventionally, a full-color copying machine or printer which is a subject of some corporate bodies due to a high price is intended for wide users including small-to-medium offices and general homes. The full-color copying machine or printer intended for such a user is required for downsized and inexpensive body more than the existing copying machine or printer. Also, the effort for the maintenance or the reduction in the running cost resulted from the effort becomes more important. Therefore, a major problem is to extend the lifespan of the belt material.

[0016] An object of the present invention is to solve the above problems contained in the related art and achieve the purpose below. That is, an object of the present invention is to provide a semiconductive belt with low resistance variation against the applied voltage or contraction in the vicinity of a support roll, and an image forming apparatus capable of obtaining an image of high quality.

[0017]

[Means for solving the Problem] The inventor found that if a resistance variation is high when a repeated distortion is applied to a semiconductive belt, the resistance variance is high due to an applied voltage according to repeated use (in practical use), expansion/contraction in a portion of a support roll or the like, and thus devised the present

invention. That is, the present invention is as follows:

[0018] <1> A semiconductive belt is characterized in that a relationship between an initial volume resistivity $\rho v1$ (Ωcm) and a volume resistivity $\rho v2$ (Ωcm) after applying a tensile repeated distortion of 3% to the belt 10,000 (10K) times satisfies Expression (1) below.

[0019] Expression (1) $|\log\rho v1 - \log\rho v2| \leq 0.5$.

[0020] <2> The semiconductive belt according to <1> is characterized in that the initial volume resistivity is 10^{8} to 10^{13} Ωcm.

[0021] <3> The semiconductive belt according to the <1> or <2> is characterized in that the belt contains at least two incompatible materials.

[0022] <4> The semiconductive belt according to any one of the <1> to <3> is characterized in that the belt is provided with a surface coating layer made of low-surface energy material.

[0023] <5> The semiconductive belt according to the <4> is characterized in that the low-surface energy material is dispersed with particles of fluorine resin.

[0024] <6> An image forming device including a transfer carrying belt for carrying a transfer body to a transfer region in which a toner image is transferred onto the transfer body, the transfer carrying belt being a semiconductor belt according to any one of the <1> to <5>.

[0025]

[Embodiments of the Invention] In a semiconductive belt of

the present invention satisfies, a relationship between an initial volume resistivity ρv1 (Ωcm) and a volume resistivity ρv2 (Ωcm) after applying a tensile repeated distortion of 3% to the belt 10,000 (10K) times satisfies Expression (1) below, preferably Expression (1-A) below, and more preferably Expression (1-B) below. Herein, the volume resistivity ρv1 and the volume resistivity ρv2 are a volume resistivity in a widthwise direction.

[0026] Expression (1) $|\log\rho v1-\log\rho v2|\leq 0.5$

Expression (1-A) $|\log\rho v1-\log\rho v2|\leq 0.4$

Expression (1-B) $|\log\rho v1-\log\rho v2|\leq 0.3$

[0027] According to the semiconductive belt of the present invention, if a volume resistivity variation is out of the range of Expression (1) above, a resistance variation resulted from the applied voltage or contraction in the vicinity of a support roll is increased, and thus a lifespan is shortened due to the repeated use (in practical use). In general, the semiconductive belt is configured to disperse a conductive agent into a binder resin. For this reason, the semiconductive belt of the present invention satisfies Expression (1) above, so that it seems to suppress the formation of a new conductive path due to the resistance change of the binding resin itself or the change in the state of conductive agent dispersion. By means of selection of various materials such as binding resin, conductive agent or the like which constitutes the semiconductive belt of the present invention, adjustment of compound amounts and

dispersion condition, layer configuration, optimization of a fabricating method or the like, it is possible to adjust the volume resistivity variation within the range satisfying Expression (1) above in the semiconductive belt of the present invention.

[0028] In the semiconductive belt of the present invention, the expression 'tensile repeated distortion of 3%' means an amount of distortion applied by attaching a sheet (semiconductive belt), which is cut to have a width of 50 mm and a length of 200 mm, to chucks, which are extended in a distance of 150 mm, of a tensile test device, and alternatively changing the distance of the chucks between 154.5 mm (distortion of 3%) and 150 mm at chuck speed of 12 mm/min.

[0029] In the semiconductive belt of the present invention, the volume resistivity can be measured according to JIS K6991 by using a circular electrode (e.g., a Highrester IP HR probe produced by Mitsubishi Petrochemical Co., Ltd.). More specifically, for example, the volume resistivity can be measured by using the circular electrode illustrated in Fig. 1. Fig. 1 is a schematic plan view (a) and a schematic cross-sectional view (b) illustrating one example of the circular electrode. The circular electrode shown in Fig. 1 includes a first voltage applying electrode A and a second voltage applying electrode B. The first voltage applying electrode A has a columnar electrode part C and a cylindrical ring electrode part D having a larger inner diameter than the

outer diameter of the columnar electrode part C and surrounding the columnar electrode C at a uniform interval. A conductive belt T is held between the columnar electrode part C and ring electrode part D of the first voltage applying electrode A and the second voltage applying electrode B, a voltage V (V) is applied between the columnar electrode part C of the first voltage applying electrode A and the second voltage applying electrode B, a flowing current I (A) is measured, and the volume resistivity $\rho v1$ (Ωcm) of the semiconductive belt T can be calculated according to Expression (2) below. In Expression below, t refers to the thickness of the semiconductive belt T.

[0030] Expression (2) $\rho v1=19.6\times(V/I)\times t$

[0031] In the semiconductive belt of the present invention, it is preferable that the initial volume resistivity is 10^8 Ωcm to 10^{11} Ωcm, and preferably 10^9 Ωcm to 10^{10} Ωcm in view of stably holding a transfer material by electrostatic absorption. If the initial volume resistivity is less than 10^8 Ωcm, since electric charge easily flows, the transfer material may not be held by the electrostatic absorption. Meanwhile, if the initial volume resistivity exceeds 10^{11} Ωcm, since high voltage is required in order to let the belt to hold the transfer material, electric discharge easily happens. Thus, a part of the toner on the transfer material has a reverse polarity, and an image failure such as pinhole is partially produced on the transfer material. For this reason, there is a case in which since the transfer image is easily

disturbed, it is difficult to obtain the image of good quality.

[0032] Next, the configuration of the semiconductive belt of the present invention will be described in detail. It is preferable that the semiconductive belt of the present invention is made of an elastic layer composed of a binder resin and a conductive agent. In the semiconductive belt of the present invention, the elastic layer may be formed of single layer or plural layers. Alternatively, if necessary, a surface coating layer is formed on the surface of the elastic layer.

[0033] The binder resin includes rubber material (e.g., polyurethane, chlorinated polyisoprene, NBR, chloroprene rubber, EPDM, hydroxylated polybutadiene, butyl rubber, silicon rubber, and a rubber blended material consisted of at least two components thereof), resin material (e.g., polyester, polyether ether ketone, polyimide, polycarbonate, polyvinylidene fluoride, and resin blended material consisted of at least two components thereof),and rubber/resin blended material consisted of at least two components thereof. Herein, single use of polyether ether ketone, polycarbonate, and polyvinylidene fluoride is not preferable since it causes generation of crack when the tensile repeated distortion is applied.

[0034] As the conductive agent, carbon black (e.g., furnace black, acetylene black, ketjen black, channel black or the like) is generally preferred from the viewpoint of costs. In

addition to this, metal, metal oxide, surface-active agent, conductive polymer or the like may be used. These conductive agents can be used either alone or in combination of two or more types.

[0035] The metal includes graphite, aluminum, nickel, copper, and an alloy thereof. The metal oxide includes, for example, tin oxide, zinc oxide, potassium titanate, a tin oxide-indium oxide composite oxide and a tin oxide-antimony oxide complex oxide. The surface active agent includes a surfactant such as sulfonate, ammonia salt, or the like, and various surfactants such as cationic type, anionic type, and nonionic type. Example of the conductive polymer include polymers with a quaternary ammonium salt group such as various (e.g., styrene) copolymers of (meth)acrylate having a carboxylic group with a quaternary ammonium salt group, and copolymers of maleimide and methacrylate with a quaternary ammonium salt group, polymers having alkali metal sulfonate salt such as sodium polysulfonate, and polymers having at least hydrophilic unit of alkylene oxide bonded in molecular chain. Concrete examples of the conductive polymer include, for example, polyethylene oxide, polyethylene glycol type polyamide copolymer, polyethylene oxide-epichlorohydrine copolymer, block polymer having polyether amide imide or polyether as a main segment, and further polyaniline, polythiophene, polyacetylene, polypyrrole, polyphenylene vinylene, and so forth. These conductive polymers can be used in either undoped state or doped state.

[0036] It is preferable that by using these conductive agents, surface-active agents, and conductive agent either alone or in combination of two or more types, a volume resistance can be stably obtained.

[0037] In a case in which two or more kinds of carbon blacks are combined as two or more kinds of conductive agents, it is preferable that two or more kinds of carbon blacks with different DBP oil absorption are combined. By combining two or more kinds of carbon blacks with different DBP oil absorption in a specific ratio, it is possible to prevent the abrupt change of the volume resistivity (e.g., in the range of 10^8 to 10^{10} Ωcm), thereby imparting electroconductivity with relatively small amounts.

[0038] Carbon black to be used as an electrically conducting agent tends to form a chainlike bond in a rubber composition in which it is incorporated. The rubber composition exhibits different resistivities depending on the length of such a chainlike bond. Meanwhile, if this chainlike bond is long, the electrical conductivity of the interlayer is improved and the resistivity of the interlayer is lowered. On the contrary, if this chainlike bond is short, the electrical conductivity of the interlayer is lowered and the resistivity of the interlayer is raised. In other words, if carbon black which forms a long chainlike bond is incorporated in a rubber composition, the resistivity of the intermediate transfer belt changes greatly as compared with the case where carbon black which form a short chainlike bond is incorporated in

the rubber composition in the same amount.

[0039] The length of the chainlike bond depends on the particle size or surface activity of individual carbon black particles. One of indexes of the length of chainlike bond is DBP (dibutyl phthalate) oil absorption defined in ASTM (America Society for Testing and Materials) D2414-6TT. This DBP oil absorption is represented by an amount of DBP (ml) to be absorbed by 100 g of carbon black. It is said that carbon black having a higher DBP absorption, i.e., higher oil absorption forms a longer chainlike bond.

[0040] If the resistivity of the semiconductive belt is adjusted merely by incorporating only carbon black having a high DBP oil absorption, the resistivity of the semiconductive belt can change with a slight change of the blended amount of carbon black. Thus, the semiconductive belt cannot be provided with a predetermined resistivity unless the blended amount and dispersion condition of carbon black are strictly defined.

[0041] On the other hand, if the resistivity of the semiconductive belt is adjusted merely by incorporating only carbon black having a low DBP oil absorption, the carbon black can be dispersed in the rubber composition more uniformly than the case where only carbon black having a high DBP oil absorption is incorporated, giving less resistivity change with the change of the blended amount of carbon black. However, in order to provide the semiconductive belt with a predetermined resistivity, it is necessary that carbon black

be incorporated greater than the case where carbon black having a high DBP oil absorption is incorporated. As a result, the mixing proportion of carbon black in the rubber composition is raised to give a rubber composition having a raised viscosity which can hardly be processed when kneaded by means of a Banbury mixer, kneader or the like.

[0042] Accordingly, two or more carbon blacks having different DBP oil absorptions may be preferably used in combination.

[0043] As the carbon blacks to be incorporated in the blending rubber material there maybe any carbon blacks having different DBP oil absorptions. However, if the different in DBP oil absorption between these carbon blacks is too small, it can produce results similar to that of the case where only one kind of carbon black is incorporated in the rubber composition. Accordingly, as carbon blacks there may be preferably used those differing in DBP oil absorption to some extent. More specifically, the carbon black having a high DBP oil absorption preferably exhibits oil absorption of not less than 250 ml/100 g, and the carbon black having a low DBP oil absorption preferably exhibits oil absorption of not more than 100 ml/100 g.

[0044] Examples of the carbon black having high oil absorption include particulate acetylene black (oil absorption of 288 ml/100 g; produced by DENKI KAGAKU KOGYO K. K.), kitchen black (oil absorption of 360 ml/100 g; produced by Lion Akzo Co., Ltd.), Balkan XC-72 (oil absorption of 265

ml/100 g; produced by Cabot Specialty Chemicals Inc.), and acetylene black such as HS-500 (oil absorption of 447 ml/100 g; produced by Asahi Carbon Co., Ltd.). Examples of the carbon black having a low DBP oil absorption include Asahi Thermal FT (oil absorption of 28 ml/100 g; produced by Asahi Carbon Co., Ltd.) and Asahi Thermal MT (oil absorption of 35 ml/100 g; produced by Asahi Carbon Co., Ltd.). As combination of two or more carbon blacks having different DBP oil absorptions, in the case of the combination of two kinds, the combination of the particulate acetylene black (oil absorption of 288 ml/100 g; produced by DENKI KAGAKU KOGYO K. K.) as the carbon black having high oil absorption and the Asahi Thermal FT (oil absorption of 28 ml/100 g; produced by Asahi Carbon Co., Ltd.) as carbon black having a low DBP oil absorption is preferable.

[0045] It is preferable that the semiconductive belt of the present invention contains at least two kinds of incompatible materials. More specifically, for example, the containment of at least two kinds of incompatible binder resins is preferable in view of that a dispersed state of the conductive agent is good and a specific volume resistivity can be stably obtained.

[0046] The at least two kinds of incompatible binder resins is combination of binder resins with different in a solubility parameter δ(SP value). Herein, it is preferable that the different in the solubility parameter δ(SP value) has, for example, 1.3 $J^{1/2}$ $cm^{3/2}$ or more.

[0047] The solubility parameter δ(SP value) is expressed by Expression (3) below. Wherein δ2d, δ2p' and δ2h represents dispersion force, polar effect, and SP value based on hydrogen bond, respectively. In general, Supposing that the cohesive energy is E (cal=4.1868 J) and the molar value is Vm, the solubility parameter δ(SP value) is a value represented by δ=(E/Vm)1/2. It is known that the greater SP value is, the higher is the polarity of the substance.

[0048] Expression (3) δ=δ2d+δ2p'+δ2h

[0049] Examples of the rubber material having a high SP value include urethane rubber (SP value=10), chlorinated polyisoprene rubber (SP value=9.35), NBR (SP value=9.3) and chloroprene rubber (SP value=8.71). Examples of the rubber material having a low SP value include EPDM (SP value=8.0), hydrogenated polybutadiene rubber (SP value=8.08), butyl rubber (SP value=7.85), and silicone rubber (SP value=7.45). Examples of the resin material having a high SP value include polyacrylonitrile (SP value=13.55), polyvinyl alcohol (SP value: 12.60), epoxy resin (SP value=10.9), polyvinyl chloride (SP value=9.74), polyvinyl acetate (SP value=9.57), and polystyrene (SP value=9.03). Examples of the resin material having a low SP value include polyethylene (SP value=7.88), polyisobutylene (SP value=7.7), and poly-tetra-fluoroethylene(SP value=6.2).

[0050] When at least two kinds of incompatible binder resins are combined, since they are not mixed with each other, a phase having "sea phase" and "island phase" is obtained. For

this reason, when the conductive agent is dispersed in at least two kinds of incompatible binder resins, it is divided into a phase having the conductive agent unevenly dispersed therein and a phase having the conductive agent evenly dispersed therein, to obtain an electrically conductive phase having the conductive agent densely dispersed therein. That is, the conductive agent is densely dispersed at an interface of two kinds of binder resins to form an unevenly dispersed state, and the dense portion contributes to electrical conduction, making it possible to form a stable electrically conducting path. Further, if the amount of the conductive agent is increased, the hardness of the elastic belt is increased, but the amount of the conductive agent is reduced, thereby inhibiting the rise in the hardness of the belt. By adjusting mixture ratio of at least two kinds of incompatible binder resins and the amount of the conductive agent, it is possible to stably obtain the target volume resistivity (e.g., 10^{8} to 10^{11} Ωcm).

[0051] Fig. 2 is a view schematically illustrating a state of the carbon black dispersed in the incompatible binder resins of EPDM (SP value=8.0) and NBR (SP value=9.3). As shown in Fig. 2, by blending and forming NBR which is compatible with the carbon black and EPDM which is incompatible with the NBR, the phase having the sea phase (EPDM) and the island phase (NBR) exists. It is divided into the phase (EPDM) having the carbon black unevenly dispersed therein and the phase (NBR) having the conductive agent

evenly dispersed therein, so that an electrically conductive phase having the carbon black densely dispersed therein exists at the interface.

[0052] If necessary, it is preferable to form a surface coating layer on the surface of the semiconductive belt of the present invention. In the case in which the surface coating layer is made of a low surface energy material, it is possible to prevent toner dirt on the surface of the semiconductive belt and prevent dirt of the transfer material based on toner on the belt surface.

[0053] The low surface energy material is preferably a material wherein fluorine resin particles are dispersed. The fluorine resin particles is not particularly limited. Examples thereof include polyvinyl fluoride, PVDF, tetrafluoroethylene (TFE) resin, chlorotrifluoroethylene (CTFE) resin, ethylene-tetrafluoroethylene copolymer (ETFE), CTFE-ethylene copolymer, PFA (TFE-perfoluoroalkyl vinyl ether copolymer), FEP (TFE-hexafluoropropypene (HFP) copolymer), and EPE (TFT-HFP-perfoluoroalkyl vinyl ether copolymer). More specifically, an example of TFE resin powder is KTL-500F having a particle size of 0.3 to 0.7 μm (made by Kitamura Limited).

[0054] The fluorine resin particles are dispersed in a resin material and used. Examples of this resin material include aliphatic polyester resins wherein polymer segments are bonded to each other in a linear chain form, such as VYLON 30SS, VYLON 200, and VYLON 300 made by TOYOBO CO., LTD.,

polyurethane resins having a soft segment in their molecule, and fluorine rubber. Since these resin materials themselves have flexibility, the resin materials can give flexibility to the surface coat layer. Thus, the generation of cracks or the like can be prevented.

[0055] The surface coating layer may contain a conductive agent. As this conductive agent, the above-mentioned conductive agent can be used. From the viewpoint of costs, carbon black is particularly preferred.

[0056] The surface coating layer can be formed by applying the following onto the surface of the semiconductive belt: an electroconductive paint wherein appropriate amounts of PTFE (polytetrafluoroethylene) resin particles and carbon black are dispersed in an aliphatic polyester resin such as VYLON 30SS, VYLON 200, and VYLON 300 made by TOYOBO CO., LTD.; a water-emulsion paint Emralon 345ESD, or Emralon JYL601ESD, made by Acheson Japan Limited, wherein carbon black is dispersed in a water-emulsion paint urethane containing PTFE (polytetrafluoroethylene) resin; or NF-940 made by DAIKIN INDUSTRIES, LTD., wherein FEP (tetrafluoroethylene-hexafluoropropylene copolymer) resin particles and carbon black are dispersed in fluorine rubber.

[0057] As the method of applying the paint, a brush-coating, dipping, spray, roll coater or the like method can be used. It is preferred that the surface coating layer having a thickness of 10 to 60 μm is generally formed, for example, by the spray method. The film thickness is more preferably set

to 15 to 30 μm. If the thickness is less than 10 μm, the surface coating layer is worn off since the semiconductive belt comes into forcibly contact with an intermediate transfer member or an electrostatic latent carrier repeatedly through a sheet under pressure. As a result, the elastic layer may be exposed. In addition, when the surface coating layer is formed by the application method, the film may not be easily made uniform. On the other hand, if the film thickness is more than 60 μm, at the time of coating the elastic layer with the paint by the application method, a drip of the paint may easily be generated on the surface. Thus, a smooth and uniform paint coat may not be easily and stably formed.

[0058] (Image Forming Apparatus) The image forming apparatus according to the present invention includes a transfer carrier belt carrying a material to be transferred to a transfer region in which the toner image is transferred onto the transfer material. The transfer carrier belt is the semiconductive belt of the present invention. The transfer carrying belt electrostatically adsorbs and carries the material to be transferred, and a voltage is applied to the material to be transferred from a transfer means described below by a carrier transporting belt, thereby transferring the toner image by the electric field.

[0059] The image forming apparatus of the present invention is provided with an electrostatic latent image carrier, a charging means that charges the surface of the electrostatic

latent image carrier uniformly, an exposing means that exposes the surface of the electrostatic latent image carrier to form an electrostatic latent image, a developing means that develops the electrostatic latent image formed on the surface of the electrostatic latent image carrier with an electrostatic image developer to form a toner image, a transfer means that transfers the toner image to a surface of a body to be transferred, a fixing means that fixes the toner image on the surface of the body to be transferred, a cleaning means that removes toner and dirt adhering to an electrophotographic photoreceptor, an electrification-removing means that removes the electrostatic latent image remaining on the surface of the electrostatic latent image carrier, and so on in a known manner when needed.

[0060] The electrostatic latent image carrier may be any known one. As the photosensitive layer thereof, a known layer such as an organic or amorphous silicon layer can be used. In the case in which the electrostatic latent image carrier is cylindrical, the carrier can be obtained by a known method, for example, a method of extruding aluminum or aluminum alloy and then subjecting the extruded product to surface working. In addition, the electrostatic latent image carrier in a belt form can be used.

[0061] The kind of the charging means is not particularly limited. Examples thereof include known charging devices such as contact type charging devices using an electroconductive or semiconductive roll, brush, film, rubber

blade or the like; and a scorotron or corotron charging device using corona discharge. Among these devices, the contact type charging devices are preferred since they are superior in electrification compensation ability. The charging means usually applies a direct current to the electrophotographic photoreceptor. However, an alternative current may be further superposed thereon and applied thereto. In addition, the electrification can be preferably performed using the charging means. The electrophotographic photoreceptor is usually electrified to, for example, -300 to -1000 V by means of such a charging means.

[0062] The kind of the exposing means is not particularly limited. Examples thereof include optical instruments capable of exposing, in a desired image form, the surface of the electrophotographic photoreceptor to light from a light source such as a semiconductor layer, an LED or a liquid crystal shutter, or through a polygon mirror from such a light source.

[0063] The developing means may be a developing device appropriately selected dependently on a purpose. Examples thereof include known developing devices for developing a latent image with a single-composition developer or a two-component developer in a non-contact manner or a contact manner using a brush, a roll or the like.

[0064] The transfer means may be a contact type transfer device wherein a transfer roll is brought into pressure contact with the rear surface of the semiconductive belt to

transfer a toner image onto the body to be transferred, a non-contact type transfer device wherein a corotron or the like is used to transfer a toner image onto the body to be transferred. In addition, the semiconductive belt of the present invention can be used as an intermediate transfer body in an image forming apparatus of an intermediate transfer type. In this instance, the toner image is transferred onto the intermediate transfer body by a first transfer means (hereinafter, referred to as 'first transfer'), and the toner image is transferred onto the body to be transferred from the intermediate transfer body by a second transfer means (hereinafter, referred to as 'second transfer).

[0065] The first transfer means includes a contact type transfer charging unit using, for example, a belt, a roll, a film, a rubber blade or the like, and a known transfer charging unit such as a scorotron transfer charging unit using corona discharge or a corotron transfer charging unit. Among them, the contact type transfer charging unit is preferable in view of the good transfer charging compensation capability. In addition, according to the present invention, a peeling-off charging unit may be used in combination with the transfer charging unit.

[0066] The second transfer means includes a contact type transfer charging unit using such as a transfer roll, a scorotron transfer charging unit, and a corotron transfer charging unit which are illustrated as the first transfer means. Among them, similar to the first transfer means, the

contact type transfer charging unit is preferable. The transfer state of the image can be maintained in a good state by forcibly pressing the image with the contact type transfer charging unit such as a transfer roll. In addition, if the contact type transfer charging unit such as a transfer roll is pressed at a position guiding the intermediate transfer body, it is possible to perform the action of transferring the toner image from the intermediate transfer body to the body to be transferred in a good state.

[0067] The optical electrification removing means includes, for example, a tungsten lamp and an LED. As a light quality used in the optical electrification-removing process, there are, for example, white light such as tungsten lamp or the like, or red light such as LED light or the like. The light irradiating intensity in the optical-static removing process is generally set to be several times or 30 times of light amount displaying a half exposure sensitivity of an electrophotographic photoreceptor.

[0068] The fixing means is not specifically limited, and includes a known fixing unit, for example, a heat roll fixing unit, an oven fixing unit or the like.

[0069] The cleaning means is not specifically limited, and a known cleaning device may be used.

[0070] The following will describe one example of the image forming apparatus of the present invention. Fig. 3 and Fig. 4 are a schematic diagram illustrating one example of the image forming apparatus according to the present invention.

[0071] The image forming apparatus illustrated in FIG. 3 has an electrophotographic photoreceptor (electrostatic latent image carrier) 20, a recording paper carrying belt (transfer carrying belt) 21, a transfer roll (bias roll serving as a transfer electrode) 22, a recording paper (body to be transferred) tray 23, and a fixing unit 24. As the recording paper carrying belt 21, a semiconductive belt of the present invention is provided.

[0072] The developing device 25 using B (black) toner, and an exposing device and a charging device (not shown) are set in the vicinity of the electrophotographic photoreceptor 20. The electrophotographic photoreceptor 20 is arranged to be rotated in a clockwise direction shown by an arrow at a given peripheral velocity (process speed).

[0073] The recording paper carrying belt 21 can be rotated in a counterclockwise shown by an arrow at the same peripheral velocity as the electrophotographic photoreceptor 20 by means of supporting rolls 27 and 28. A portion of the belt 21, which is positioned in the middle of the supporting rolls 27 and 28, is arranged to contact the electrophotographic photoreceptor 20.

[0074] The transfer roll 22 is arranged inside the recording paper carrying belt 21 and at a position opposite to the portion where the recording paper carrying belt 21 and the electrophotographic photoreceptor 20 contact each other, and makes a transfer region (nip section) for transferring a toner image T onto the recording paper (body to be

transferred) P through the electrophotographic photoreceptor 20 and the recording paper carrying belt 21.

[0075] The recording paper tray 23 has a pickup roll 26. By means of the pickup roll 26, the recording paper T is carried from the recording paper tray 23 to the recording paper carrying belt 21.

[0076] The fixing device 9 is arranged in such a manner that the recording paper can be carried after the paper is passed through the transfer region (nip section) between the electrophotographic photoreceptor 20 and the transfer roll 22 across the recording paper carrying belt 21.

[0077] In the image forming apparatus illustrated in Fig. 3, the electrophotographic photoreceptor 20 rotates in the direction shown in the arrow, so that its surface is uniformly electrified by the charging device (not shown). The exposing device (not shown) forms an electrostatic latent image in B (black) on the electrified electrophotographic photoreceptor 20. This electrostatic latent image is developed with toner by the developing device 25 so that a visualized toner image T is formed. The toner image T arrives at the transfer region (nip section) where the transfer roll 22 is arranged by the rotation of the electrophotographic photoreceptor 20. At the same time, the recording paper T is electrostatically adsorbed on the recording paper carrying belt 21 and carried to the transfer region (nip section). By applying a reversely-polar electric field to the toner image T from the transfer roll 22, the

toner image P is electrostatically transferred onto the surface of the recording paper P adsorbed on the recording paper carrying belt 21. The recording paper T on which the toner image T is transferred by the transfer roll 22 is further carried to the fixing device 9 so that the toner image is fixed. Through the abovementioned steps, a desired image is formed on the surface of the recording paper P.

[0078] The image forming apparatus shown in Fig. 4 can be used as a copying machine, a laser beam printer or the like. The image forming apparatus shown in Fig. 4 has units Y, M, C and Bk, a recording paper (body to be transferred) carrying belt 6, transfer rolls 7Y, 7M, 7C, and 7Bk, a recording paper carrying roll 8, and a fixing unit 9. As the recording paper (body to be transferred) carrying belt 6, a semiconductive belt of the present invention is provided.

[0079] The units Y, M, C and Bk is provided with electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk (although not shown, a flange is fixed to the electrophotographic photoreceptors) which are respectively arranged to be rotated in a clockwise direction shown by an arrow at a given peripheral velocity (process speed). Around the electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk, corotron charging units 2Y, 2M, 2C and 2Bk, exposing units 3Y, 3M, 3C and 3Bk, each of color developing unit (a yellow developing unit 4Y, a magenta developing unit 4M, a cyan developing unit 4C, and a black developing unit 4Bk), and an electrophotographic photoreceptor cleaners 5Y, 5M, 5C and 5Bk

are arranged.

[0080] Although the units Y, M, C and Bk are arranged in parallel in the order of units Y, M, C and Bk with respect to the recording paper carrying belt 6, the proper order may be set in conformity of the image forming method, such as the order of the units Bk, Y, C and M.

[0081] The recording paper carrying belt 6 can be rotated in a counterclockwise shown by an arrow at the same peripheral velocity as the electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk by means of supporting rolls 10, 11, 12 and 13. A portion of the recording paper 9 of the belt 6, which is positioned in the middle of the supporting rolls 12 and 13, is arranged to contact the electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk, respectively. The recording paper carrying belt 6 is provided with a belt cleaning device 14.

[0082] The transfer rolls 7Y, 7M, 7C and 7Bk are respectively arranged inside the recording paper carrying belt 6 and at a position opposite to the portion where the recording paper carrying belt 6 and the electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk contact each other, and makes a transfer region (nip section) for transferring a toner image onto the recording paper (body to be transferred) P through the electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk and the recording paper carrying belt 21.

[0083] The fixing device 9 is arranged in such a manner that the recording paper can be carried after the paper is passed through the transfer region (nip section) between each of the

electrophotographic photoreceptors 1Y, 1M, 1C and 1Bk and the recording paper carrying belt 21.

[0084] The recording paper P is carried to the recording paper carrying belt 6 by the recording paper carrying roll 8.

[0085] In the image forming apparatus illustrated in Fig. 4, the electrophotographic photoreceptor 1Y rotates in the unit Y. In conjunction with this, the corotron charging unit 2Y drives, so that the surface of the electrophotographic photoreceptor 1Y is uniformly electrified at a predetermined polarity and potential. The electrophotographic photoreceptor 1Y with uniformly charged surface is exposed in the image by the exposing unit 3Y, and an electrostatic latent image is formed on the surface thereof.

[0086] Then, the electrostatic latent image is developed by the yellow developer 4Y, so that the toner image is formed on the surface of the electrophotographic photoreceptor 1Y. At that time, the toner is either one-component base or two-component base, but it is the two-based component base herein.

[0087] The toner image passes through the transfer region (nip section) of the electrophotographic photoreceptor 1Y and the recording paper carrying belt 6. At the same time, the recording paper P is electrostatically adsorbed on the recording paper carrying belt 21 and carried to the transfer region (nip section). By applying an electric field resulted from the transfer bias applied from the transfer roll 7Y, the toner image is electrostatically transferred onto the surface of the recording paper P in sequence.

[0088] After that, the toner remaining on the electrophotographic photoreceptor 1Y is cleaned and removed by the electrophotographic photoreceptor cleaner 5Y. The electrophotographic photoreceptor 1Y is transferred to a next transfer cycle.

[0089] The above transfer cycle is similarly performed in the units M, C and Bk.

[0090] The recording paper P on which the toner image is transferred by the transfer rolls 7Y, 7M, 7C and 7Bk is further carried to the fixing device 9 so that the toner image is fixed. Through the abovementioned steps, a desired image is formed on the surface of the recording paper.

[0091]

[Examples] The present invention will be described in detail by way of Examples hereinafter. In this instance, the present invention is not limited to these examples. In this instance, the word 'part(s)' in the sentence means 'part(s) by mass'.

[0092] Measurement of volume resistivity

The measurement of the volume resistivity according to this example is performed; a voltage of 500 V was applied by using the circular electrode illustrated in Fig. 1 (Highrester IP HR probe produced by Mitsubishi Petrochemical Co., Ltd.; an external system of a first voltage applying electrode A is φ16 mm, an inner diameter of a ring-shaped electrode B is φ30 mm and an outer diameter thereof is φ40), a current value was measured after 30 seconds, and then it

wash calculated by the above-described method.

[0093] (Example 1) After the material of the composition example 1 below was kneaded with a Bumbury's mixer, the mixture was extruded into a cylindrical form with an extruder. A vulcanizing can was used to heat and vulcanize the mixture at a temperature of 120°C and a vapor pressure of 1.5 kg/cm^2 to yield an electroconductive rubber belt. Furthermore, this rubber belt was coated to the outside of a metallic substrate and then the surface was polished to yield a rubber belt (seamless belt) having a width of 320 mm, a circumferential length of 264 mm and a thickness of 0.5 mm. A water-emulsion paint (Emralon JYL-345ES, made by Acheson Japan Limited), wherein 8 parts by mass of carbon black are dispersed in urethane-modified tetrafluoro ethylene resin as urethane-modified fluoro-based resin, was spray-coated onto the surface of the obtained rubber belt to have a thickness of 20 μm. Thereafter, the belt was heated at 120°C for 35 minutes to form a surface coating layer having a thickness of 20 μm. In this way, a semiconductive belt of Example 1 was produced.

[0094] Composition Example 1

EPDM: EP-33 of 70 parts, made by JSR Co.

NBR: N230SH of 30 parts, made by JSR Co.

Particulate acetylene black (DENKI KAGAKU KOGYO K. K.): 10 parts

FT carbon (Asahi Carbon Co., Ltd.): 20 parts

Vulcanizing agent: 5 parts

Vulcanization accelerator: 2 parts

Dispersion assistant: 0.5 part

[0095] An initial volume resistivity $\rho v1$ of the obtained semiconductive belt of Example 1 was $10^{9.5}$ Ωcm. In addition, the belt having a width of 320 mm and a circumferential length of 264 mm was divided into five parts in the width direction, and divided into five parts in the circumferential direction. Thus, the volume resistivities at 25 points in the belt plane were measured. The in-plane variation (difference between the maximum value and the minimum value) in the volume resistivity was 0.3 digit (logΩcm).

[0096] (Example 2) After the material of the composition example 2 below was kneaded with a Bumbury's mixer, the mixture was extruded into a cylindrical form with an extruder. A vulcanizing can was used to heat and vulcanize the mixture at a temperature of 120°C and a vapor pressure of 1.5 kg/cm^2 to yield an electroconductive rubber belt. Furthermore, this rubber belt was coated to the outside of a metallic substrate and then the surface was polished to yield a rubber belt (seamless belt) having a width of 320 mm, a circumferential length of 264 mm and a thickness of 0.5 mm. A water-emulsion paint (Emralon JYL-345ESD, made by Acheson Japan Limited), wherein 8 parts by mass of carbon black are dispersed urethane-modified tetrafluoro ethylene resin as urethane-modified fluoro-based resin, was spray-coated onto the surface of the obtained rubber belt to have a thickness of 20 μm. Thereafter, the belt was heated at 120°C for 35 minutes to form a surface coating layer having a thickness of 20 μm.

In this way, a semiconductive belt of Example 2 was produced.

[0097] Composition Example 2

EPDM: EP-33 of 70 parts, made by JSR Co.

NBR: N230SH of 30 parts, made by JSR Co.

Particulate acetylene black(DENKI KAGAKU KOGYO K. K.): 8 parts

FT carbon (Asahi Carbon Co., Ltd.): 20 parts

Vulcanizing agent (organic peroxide): 1 part

Vulcanization accelerator: 2 parts

Dispersion assistant: 0.5 part

[0098] An initial volume resistivity ρv1 of the obtained semiconductive belt of Example 2 was $10^{12.1}$ Ωcm. In addition, the belt having a width of 320 mm and a circumferential length of 264 mm was divided into five parts in the width direction, and divided into five parts in the circumferential direction. Thus, the volume resistivities at 25 points in the belt plane were measured. The in-plane variation (difference between the maximum value and the minimum value) in the volume resistivity was 0.2 digit (logΩcm).

[0099] (Comparative Example 1) After the material of the composition example 3 below was kneaded with a Bumbury's mixer, the mixture was extruded into a cylindrical form with an extruder. A vulcanizing can was used to heat and vulcanize the mixture at a temperature of 120°C and a vapor pressure of 1.5 kg/cm^2 to yield an electroconductive rubber belt. Furthermore, this rubber belt was coated to the outside of a metallic substrate and then the surface was

polished to yield a rubber belt (seamless belt) having a width of 320 mm, a circumferential length of 264 mm and a thickness of 0.5 mm. A water-emulsion paint (Emralon JYL-345ESD, made by Acheson Japan Limited), wherein 8 parts by mass of carbon black are dispersed in urethane-modified tetrafluoro ethylene resin as urethane-modified fluoro-based resin, was spray-coated onto the surface of the obtained rubber belt to have a thickness of 20 μm. Thereafter, the belt was heated at 120°C for 35 minutes to form a surface coating layer having a thickness of 20 μm. In this way, a semiconductive belt of Comparative Example 1 was produced.

[0100] Composition Example 3

CR: 100 parts

Ketjen black (Lion Akzo Co., Ltd.): 13 parts

Vulcanizing agent (organic peroxide): 1 part

Vulcanization accelerator: 2 parts

Age resistor: 1.5 parts

[0101] An initial volume resistivity $\rho v1$ of the obtained semiconductive belt was $10^{9.4}$ Ωcm. In addition, the belt having a width of 320 mm and a circumferential length of 264 mm was divided into five parts in the width direction, and divided into five parts in the circumferential direction. Thus, the volume resistivities at 25 points in the belt plane were measured. The in-plane variation (difference between the maximum value and the minimum value) in the volume resistivity was 1.1 digit (logΩcm).

[0102] (Comparative Example 2) After the material of the

composition example 4 below was kneaded with a Bumbury's mixer, the mixture was extruded into a cylindrical form with an extruder. A vulcanizing can was used to heat and vulcanize the mixture at a temperature of 120°C and a vapor pressure of 1.5 kg/cm^2 to yield an electroconductive rubber belt. Furthermore, this rubber belt was coated to the outside of a metallic substrate and then the surface was polished to yield a rubber belt (seamless belt) having a width of 320 mm, a circumferential length of 264 mm and a thickness of 0.5 mm. A water-emulsion paint (Emralon JYL-345ESD, made by Acheson Japan Limited), wherein 8 parts by mass of carbon black are dispersed in urethane-modified tetrafluoro ethylene resin as urethane-modified fluoro-based resin, was spray-coated onto the surface of the obtained rubber belt to have a thickness of 20 μm. Thereafter, the belt was heated at 120°C for 35 minutes to form a surface coating layer having a thickness of 20 μm. In this way, a semiconductive belt of Comparative Example 2 was produced.

[0103] Composition Example 4

EPDM: 100 parts

Ketjen black (Lion Akzo Co., Ltd.): 13 parts

Vulcanizing agent: 2 parts

Vulcanization accelerator: 2 parts

Age resistor: 1.5 parts

[0104] An initial volume resistivity ρv1 of the obtained semiconductive belt of Comparative Example 2 was $10^{8.7}$ Ωcm. In addition, the belt having a width of 320 mm and a

circumferential length of 264 mm was divided into five parts in the width direction, and divided into five parts in the circumferential direction. Thus, the volume resistivities at 25 points in the belt plane were measured. The in-plane variation (difference between the maximum value and the minimum value) in the volume resistivity was 0.9 digit (logΩcm).

[0105] (Comparative Example 3) Thirteen parts by mass of Ketjen black (Lion Akzo Co., Ltd.) were added to 100 parts by mass of ETFE resin, and this mixture was blended and kneaded in a biaxial extruder to yield carbon-dispersed ETFE resin pellets. Next, this resin pellets were extrusion-shaped in a cylindrical shape by means of a monoaxial extruder to produce a carbon-dispersed ETFE resin belt having a width of 320 mm and a circumferential length of 264 mm and a thickness of 150 μm. In this way, a semiconductive belt of Comparative Example 3 was produced.

[0106] An initial volume resistivity $\rho v1$ of the obtained semiconductive belt of Comparative Example 3 was $10^{8.4}$ Ωcm. In addition, the belt having a width of 320 mm and a circumferential length of 264 mm was divided into five parts in the width direction, and divided into five parts in the circumferential direction. Thus, the volume resistivities at 25 points in the belt plane were measured. The in-plane variation (difference between the maximum value and the minimum value) in the volume resistivity was 0.6 digit (logΩcm).

[0107] <Evaluation 1> When tensile repeated distortion of 3% was applied to the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 1000 (1K) times, 2000 (2K) times, 3000 (3K) times, and 10000 (10K) times, the volume resistivity ρv2 was respectively measured. Fig. 5 is a view illustrating a variation of the volume resistivity ρv2 when tensile repeated distortion of 3% was applied to the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 1000 (1K) times, 2000 (2K) times, 3000 (3K) times, and 10000 (10K) times. According to Fig. 5, volume resistivity variations $\Delta R(\Delta R=|\log\rho v1-\log\rho v2|)$ of Examples 1 and 2 were 0.5 digit ($\log\Omega cm$) and 0.4 digit ($\log\Omega cm$), while Comparative Example 1 was 1 digit ($\log\Omega cm$), Comparative Example 2 was 0.9 digit ($\log\Omega cm$) and Comparative Example 3 was 0.7 digit ($\log\Omega cm$). Therefore, it could be understood that the volume resistivity ρv is largely varied.

[0108] <Evaluation 2> When the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 were positioned in the image forming apparatus shown in Fig. 4 as the recording paper carrying belt 6 and then were subjected to operation test, the volume resistivity ρv3 was respectively measured. In this instance, the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 were used, in which the belt was manufactured to have a thickness 0.8 mm, a width of 320 mm and a circumferential length of 845. Fig. 6 is a view illustrating

a variation of the volume resistivity ρv when the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 were positioned in the image forming apparatus shown in Fig. 4 as the recording paper carrying belt 6 and then were subjected to operation test. According to Fig. 6, it could be understood that volume resistivity variations ΔR(ΔR=|logρv1-logρv3|) of Examples 1 and 2 were 0.4 digit (logΩcm) and 0.3 digit (logΩcm), while Comparative Example 1 was 1.2 digit (logΩcm), Comparative Example 2 was 0.9 digit (logΩcm) and Comparative Example 3 was 0.8 digit (logΩcm).

[0109] <Evaluation 3> When the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 were positioned in the image forming apparatus shown in Fig. 3 as the recording paper carrying belt 21 and then were subjected to operation test, the volume resistivity ρv4 was respectively measured, and a volume resistivity variation ΔR (ΔR=|logρv1-logρv4|) was obtained. In this instance, in the image forming apparatus shown in Fig. 3, a metal roll having an outer diameter of 10.5 mm was used as the support rollers 27 and 28. Fig. 7 is a view illustrating a volume resistivity variation ΔR (ΔR=|logρv1-logρv2|) when tensile repeated distortion of 3% is applied to the semiconductive belts obtained according to Examples 1 to 2 and Comparative Examples 1 to 3 10000 (10K) times, and a volume resistivity variation ΔR(ΔR=|logρv1-logρv4|) when the semiconductive belts obtained according to Examples 1 and 2 and Comparative

Examples 1 to 3 are positioned in the image forming apparatus shown in Fig. 3 and then were subjected to operation test. According to Fig. 7, it could be understood that in the cases of Examples 1 and 2, in which the volume resistivity variations ΔR (ΔR=|logρv1-logρv2|) were within 0.5 digit when the tensile repeated distortion of 3% was applied 10K times, the volume resistivity variations ΔR (ΔR=|logρv1-logρv4|) of the semiconductive belt was within 0.4 digit at the operation test of 300 kcycle. On the contrary, it could be understood that in the cases of Comparative Examples 1 to 3, when tensile repeated distortion of 3% is applied to the semiconductive belts 10K times, the volume resistivity variations ΔR exceeded 0.5, so that the resistance variation is very high in the operation test.

[0110]

[Effects of the Invention] As described above, the present invention can provide a semiconductive belt with low resistance variation against the applied voltage or contraction in the vicinity of a support roll, and an image forming apparatus capable of obtaining an image of high quality.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is a schematic plan view (a) and a schematic cross-sectional view (b) illustrating one example of the circular electrode measuring a volume resistance.

[Fig. 2] Fig. 2 is a view schematically illustrating a state of the carbon black dispersed in incompatible binder resins

of EPDM (SP value=8.0) and NBR (SP value=9.3).

[Fig. 3] Fig. 3 is a view illustrating a general configuration of an image forming apparatus according to one embodiment of the present invention.

[Fig. 4] Fig. 4 is a view illustrating a general configuration of an image forming apparatus according to another embodiment of the present invention.

[Fig. 5] Fig. 5 is a view illustrating a variation of a volume resistivity ρv2 when tensile repeated distortion of 3% is applied to semiconductive belts 1000 (1K) times, 2000 (2K) times, 3000 (3K) times, and 10000 (10K) times.

[Fig. 6] Fig. 6 is a view illustrating a variation of a volume resistivity ρv when semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 were positioned in the image forming apparatus shown in Fig. 2 and then were subjected to operation test.

[Fig. 7] Fig. 7 is a view illustrating a volume resistivity variation ΔR when tensile repeated distortion of 3% is applied to semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 10000 (10K) times, and a volume resistivity variation when the semiconductive belts obtained according to Examples 1 and 2 and Comparative Examples 1 to 3 are positioned in the image forming apparatus shown in Fig. 3 and then were subjected to operation test.

[Description of Reference Numerals]

A: first voltage applying electrode

B: second voltage applying electrode

C: columnar electrode part

D: ring electrode part

T: semiconductive belt

Y, M, C, Bk: unit

1Y, 1M, 1C, 1Bk: electrophotograpy photoreceptor

2Y, 2M, 2C, 2Bk: corotron charging unit

3Y, 3M, 3C, 3Bk: exposing unit

4Y: yellow developing unit

4M: magenta developing unit

4C: cyan developing unit

4Bk: black developing unit

5Y, 5M, 5C, 5Bk: electropohotography photoreceptor cleaner

6: recording paper carrying belt (transfer carrying belt)

7Y, 7M, 7C, 7Bk: transfer roll

8: recording paper carrying roll

9: fixing unit

10, 11, 12, 13: support roll

14: belt cleaning device

20: electrophotography photoreceptor

21: recording paper carrying belt (transfer carrying belt)

22: transfer roll

23: recording paper tray

24: fixing unit

25: developing device

26: pickup roll

27, 28: support roll

T: toner image

P: recording paper

FIG. 2

(1) ISLAND PHASE (NBR)

(2) SEA PHASE (EPDM)

(3) CONDUCTIVE AGENT (CARBON BLACK)

FIG. 5

(1) VOLUME RESISTIVITY (logΩcm)

(2) NUMBER OF TENSILE REPEATED DISTORTION (Kcycle)

(3) EXAMPLE 1

EXAMPLE 2

COMPARATIVE EXAMPLES 1

COMPARATIVE EXAMPLES 2

COMPARATIVE EXAMPLES 3

FIG. 6

(1) VOLUME RESISTIVITY (logΩcm)

(2) NUMBER OF CYCLE OF OPERATION TEST (Kcycle)

(3) EXAMPLE 1

EXAMPLE 2

COMPARATIVE EXAMPLES 1

COMPARATIVE EXAMPLES 2

COMPARATIVE EXAMPLES 3

FIG. 7

(1) VOLUME RESISTIVITY VARIATION (ΔR)

(2) EXAMPLE 1

EXAMPLE 2

COMPARATIVE EXAMPLES 1

COMPARATIVE EXAMPLES 2

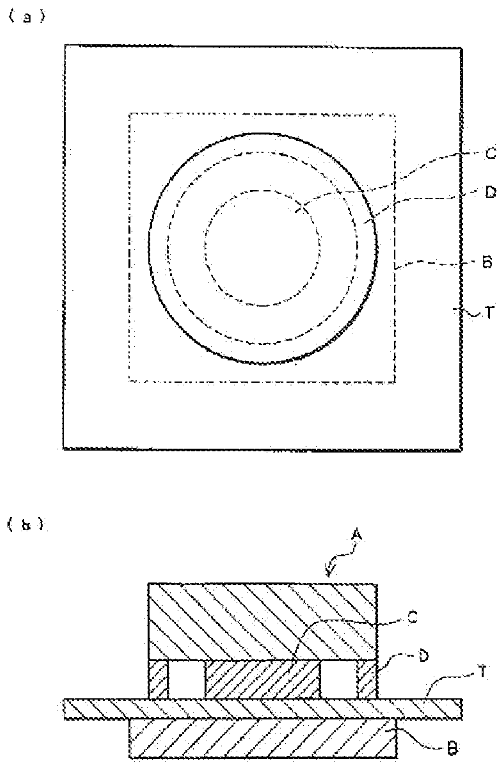
COMPARATIVE EXAMPLES 3

(3) VOLUME RESISTIVITY VARIATION WHEN THE TENSILE REPEATED DISTORTION WAS APPLIED 10 KCYCLE ($\log\Omega$cm)

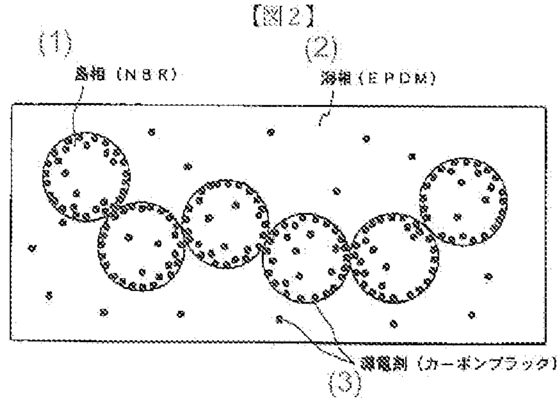
(4) VOLUME RESISTIVITY VARIATION AT THE OPERATION TEST OF 300 KCYCLE ($\log\Omega$cm)

２Ｙ、２Ｍ、２Ｃ、２Ｂｋ　コロトロン帯電器
３Ｙ、３Ｍ、３Ｃ、３Ｂｋ　露光器
４Ｙ、　イエロー現像器
４Ｍ　マゼンタ現像器
４Ｃ　シアン現像器
４Ｂｋ　ブラック現像器
５Ｙ、５Ｍ、５Ｃ、５Ｂｋ　電子写真感光体クリーナ
６　記録紙搬送用ベルト（転写搬送ベルト）
７Ｙ、７Ｍ、７Ｃ、７Ｂｋ　転写ロール
８　記録紙搬送ロール
９　定着器
＊１０、１１、１２、１３　支持ロール
１４　ベルト用クリーニング装置
２０　電子写真感光体
２１　記録紙搬送用ベルト（転写搬送ベルト）
２２　転写ロール
２３　記録紙トレイ
２４　定着器
２５　現像装置
２６　ピックアップロール
２７、２８　支持ロール
Ｔ　トナー画像
＊Ｐ　記録紙

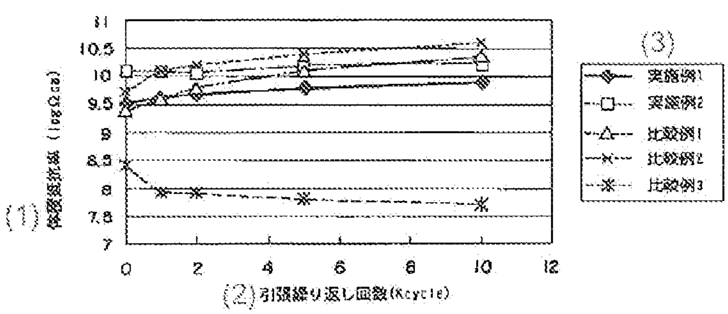
【図１】



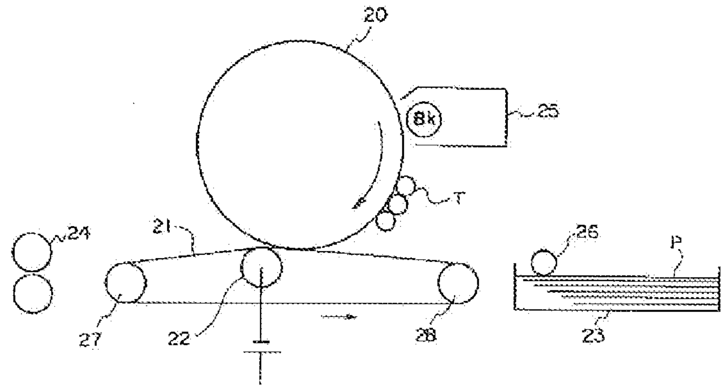
【図２】



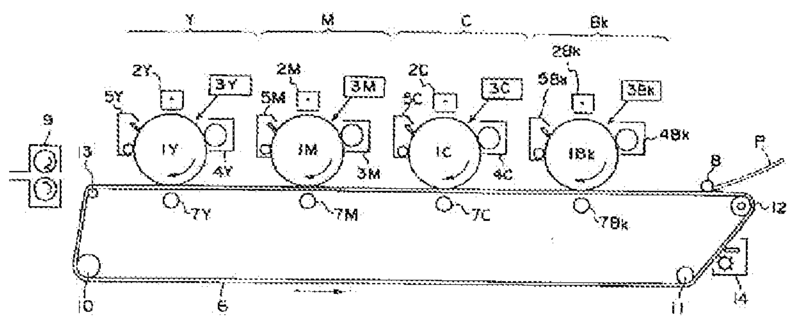
【図５】



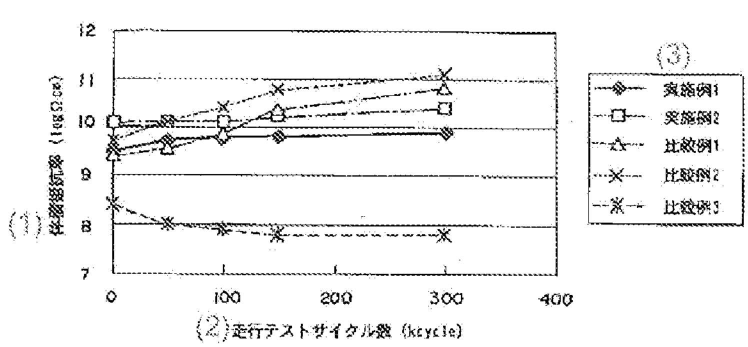
【図３】


20
25
8k
T
21
24
26
P
27
22
28
23

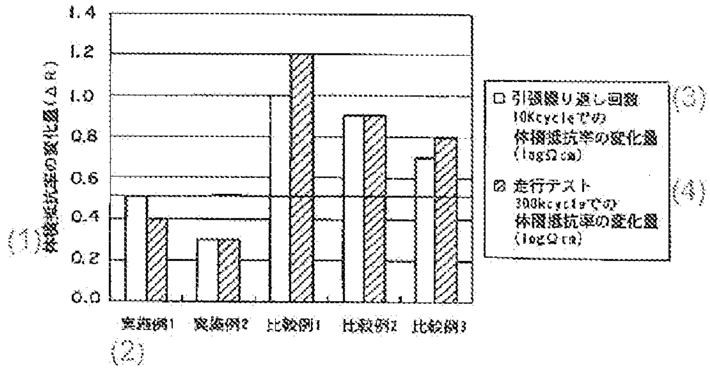
【図４】


Y
M
C
Bk
2Y
3Y
5Y
1Y
4Y
2M
3M
5M
1M
3M
2C
3C
5C
1C
4C
2Bk
3Bk
5Bk
1Bk
4Bk
9
13
7Y
7M
7C
7Bk
8
P
12
10
6
11
14

【図６】


12
11
10
9
8
7
0
100
200
300
400
(1) 体積抵抗率 (logΩcm)
(2) 走行テストサイクル数 (kcycle)
(3)
実施例1
実施例2
比較例1
比較例2
比較例3

【図７】


1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
体積抵抗率の変化量（ΔR）
(1)
実施例1
実施例2
比較例1
比較例2
比較例3
(2)
□ 引張繰り返し回数
10Kcycleでの
体積抵抗率の変化量
（logΩcm）
(3)
▨ 走行テスト
300kcycleでの
体積抵抗率の変化量
（logΩcm）
(4)